Fishery Data Series No. 98-1

Catch and Effort Statistics for the Sockeye Salmon Sport Fishery During the Early Run to the Russian River with Estimates of Escapement, 1996

by

Larry E. Marsh

February 1998

Alaska Department of Fish and Game **Division of Sport Fish**

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
ounce	oz
pound	lb
quart	qt
yard	yd

Spell out acre and ton.

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	h
minute	min
second	s

Spell out year, month, and week.

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

All commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.
All commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.
and	&
at	@
Compass directions:	
east	E
north	N
south	S
west	W
Copyright	©
Corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
et alii (and other people)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.,
id est (that is)	i.e.,
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
number (before a number)	# (e.g., #10)
pounds (after a number)	# (e.g., 10#)
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)

Mathematics, statistics, fisheries

alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	F, t, χ^2, etc.
confidence interval	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
standard length	SL
total length	TL
variance	Var

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by

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ABSTRACT

A direct expansion creel survey of the early-run Russian River recreational fishery was conducted in 1996 to determine angler effort for and harvest of sockeye salmon *Oncorhynchus nerka*. Anglers expended 225,457 angler-hours to harvest 75,203 sockeye salmon from the early run (11 June-20 July). The harvest rate for the early run was 0.334 sockeye salmon per hour of angler effort. Approximately 80% of the effort and 77% of the harvest during the early run was taken from the confluence area of the fishery.

A total of 52,905 sockeye salmon bound for spawning areas within the Russian River system were counted through the weir at the outlet of Lower Russian Lake during the early run. This escapement exceeded the Board of Fisheries mandated escapement goal of 16,000 fish.

Estimates of the age composition of the total early-run return (harvest plus escapement) indicate that the return comprised primarily age-2.3, age-2.2 and age-1.3 sockeye salmon (56%, 29% and 15%, respectively). Both the sport harvest and the total return for the early run were larger than the historical mean for 1976-1995.

Key words: Russian River, sockeye salmon, *Oncorhynchus nerka*, creel survey, direct expansion, harvest, effort, weir, escapement, age composition, recreational fishery, harvest rate.

INTRODUCTION

The Russian River is a clearwater stream located in the central Kenai Peninsula near Cooper Landing, Alaska. The drainage includes two large clearwater lakes, Upper and Lower Russian lakes, and terminates in the Kenai River approximately midway between Kenai and Skilak lakes (Figure 1). One of the largest recreational fisheries for sockeye salmon *Oncorhynchus nerka* in Alaska occurs in the Russian River and at its confluence with the Kenai River. Annual effort by anglers in this fishery has exceeded 450,000 angler-hours and annual harvests have exceeded 190,000 fish. Prior information pertaining to this fishery has been presented by Lawler (1963, 1964), Engel (1965-1972), Nelson (1973-1985), Nelson et al. (1986), Athons and McBride (1987), Hammarstrom and Athons (1988, 1989), Carlon and Vincent-Lang (1990), Carlon et al. (1991), and Marsh (1992-1996).

Sockeye salmon return to the Russian River in two temporal components, termed early and late runs. Historically, the total return during the early run has averaged approximately one-half that of the total return during the late run. The early run typically arrives at the confluence of the Russian and Kenai rivers in early June. Early-run fish typically remain in the confluence area for up to 2 weeks before continuing their upstream migration. By mid July, these fish will have migrated through the Russian River and into Upper Russian Lake. The early run spawns almost exclusively in Upper Russian Creek (Nelson 1973, 1974) and comprises primarily 3-ocean fish (Nelson 1973-1985, Nelson et al. 1986, Athons and McBride 1987, Hammarstrom and Athons 1988 and 1989, Carlon and Vincent-Lang 1990, Carlon et al. 1991, Marsh 1992-1996).

The early run of sockeye salmon bound for the Russian River is utilized predominantly by the recreational fishery. The run migrates through the waters of Cook Inlet prior to the opening of the commercial fishery which would intercept the stock. Numerically, this stock is much smaller than the later arriving Kenai River mainstem stocks, which include the late-run Russian River sockeye salmon. The early-run fish tend to migrate rapidly through the Kenai River which therefore minimizes the possibility for harvest in the mainstem Kenai River. As such, all management decisions regarding harvest and stock conservation issues for the early run are focused upon the confluence area of the Kenai and Russian rivers and a short stretch of the mainstem Russian River.

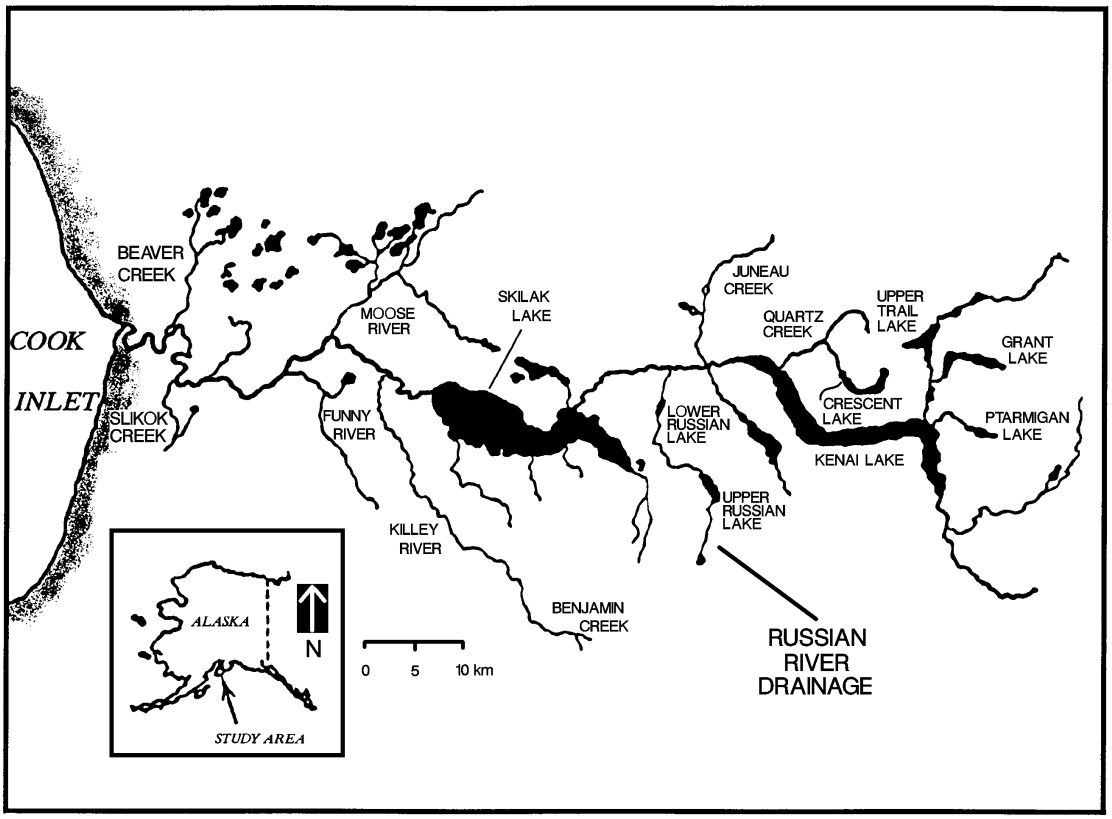

Figure 1.-Map of the Kenai and Russian River drainages.

The Division of Sport Fish of the Department of Fish and Game manages the recreational fishery to ensure that a minimum number of spawning sockeye salmon from each run passes through a weir at the outlet of Lower Russian Lake (Figure 2). The current escapement goal for the early run is 16,000 fish. This goal is based upon evaluation of returns from past brood years. With the exception of 1989, the escapement goal has been achieved each year since the goals were formally adopted in 1979. Despite an emergency closure of the early-run fishery in 1989 (1 July through 15 July), the early-run escapement goal was not achieved (Carlon and Vincent-Lang 1990).

Given that the recreational fishery for sockeye salmon at the Russian River is one of the largest in the state in terms of angler effort, there is a potential for overharvest. Precise and timely management decisions are required to ensure that adequate spawning escapement is obtained. The data necessary for these decisions are provided by a creel survey and an escapement counting weir. The creel survey provides data regarding angler effort and harvest from the recreational fishery which occurs in the Kenai/Russian River "fly-fishing-only" area (Figure 2) and in a short stretch, approximately 4.2 km (2.5 miles), of the mainstem Russian River. Weir operations provide daily escapement information. Estimates of the total inriver return (harvest plus escapement) and the age, sex, and size compositions of the return provide necessary information to evaluate production and to estimate optimum spawning escapement levels.

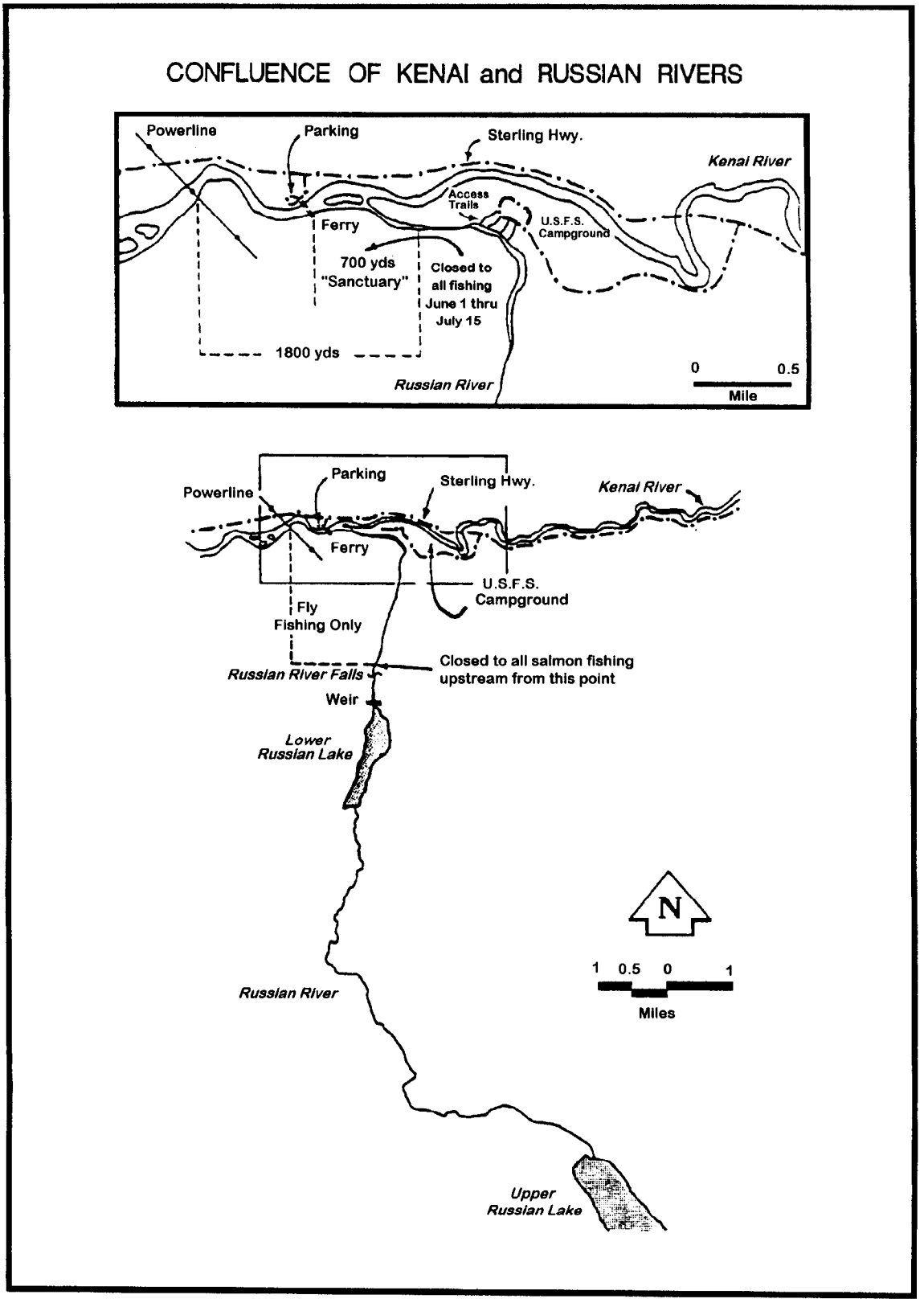

Figure 2.-Detailed map of the Kenai River and Russian River study area.

From 11 June through 20 August 1996, the daily bag and possession limit for sockeye salmon taken from the Kenai/Russian River "fly-fishing-only" area was three fish of 406 mm (16 in) or more in length. Within this area, from a marker located 540 m (600 yd) downstream from the Russian River falls to a marker located on the Kenai River 1,620 m (1,800 yd) downstream from the confluence with the Russian River, only a single-hook unbaited, unweighted fly with a point-to-shank measurement of 9.5 mm (3/8 in) or less constituted legal terminal tackle. Any weights attached to the line were required to be a minimum of 457 mm (18 in) above the hook. Within this "fly-fishing-only" area, there is a sanctuary area which begins in the Russian River 137 m (150 yd) upstream of the confluence with the Kenai River and extends downstream to a marker placed approximately 25 m (75 ft) downstream of the ferry cable (approximately 640 m). This area is closed to all fishing from 1 June to 15 July by regulation.

The objectives of this report are to present for 1996: (1) estimates of effort and harvest of early-run sockeye salmon for the Russian River recreational fishery, (2) estimates of the escapement of the early run of sockeye salmon, and (3) estimates of the age, sex, and length distributions of the harvest and escapement of the early run of sockeye salmon.

METHODS

STUDY AREA

The recreational fishery occurs in two areas (Figure 3): (1) the confluence area, which extends from the upper limit marker of the sanctuary area downstream approximately 1.6 km to a marker on the Kenai River identifying the downstream limit of the "fly-fishing-only" area; and (2) the river area, which extends from the upper limit of the sanctuary area upstream approximately 3.2 km on the Russian River to a marker identifying the upper limit of the "fly-fishing-only" area.

Primary access to the confluence and river fishing areas is provided at two locations. The United States Forest Service (USFS) campground located on the east side of the Russian River provides four short trails which intersect the main riverside trail affording access to the river area. These trails serve four camping/parking areas within the Russian River Campground. These areas are designated with the following names (Figure 3): (1) Grayling, (2) Rainbow Trout, (3) Pink Salmon, and (4) Red Salmon. Primary access to the confluence area of the Kenai and Russian rivers is through a parking and campground area administered by the United States Fish and Wildlife Service (USFWS) and located on the north bank of the Kenai River directly across from the Russian River confluence. Immediately adjacent to the USFWS parking area is a cable ferry which traverses the Kenai River. Most anglers fishing the confluence area use the ferry to reach the south bank of the Kenai River. Both the parking area and the ferry are operated privately under a concession administered by the USFWS. Some anglers also use the ferry to cross the Kenai River and then walk upstream to fish the Russian River area, while other anglers use the USFS campground trails to gain access to the confluence area.

A stationary weir, constructed of metal and wood, is located just downstream from the outlet of Lower Russian Lake and approximately 360 m (400 yd) upstream from the Russian River falls. The weir has been described in detail by Nelson (1976) and provides a complete count of the early-run spawning escapement.

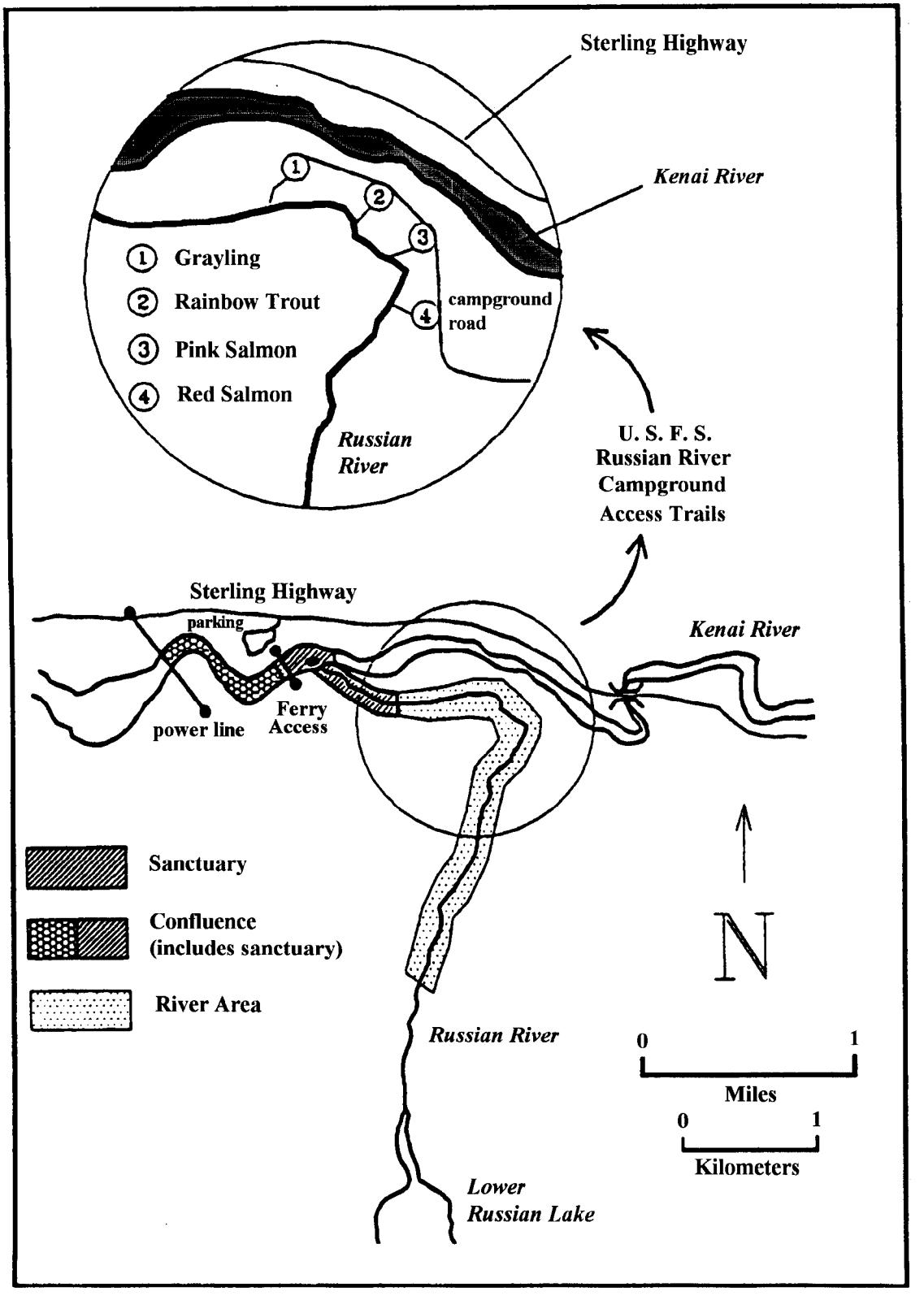

Figure 3.-Map of the Russian River sockeye salmon recreational fishing areas and fishing access locations sampled during the 1996 creel survey.

STUDY DESIGN

Creel Survey

Inseason management of the sport fishery during the past six seasons has utilized the daily harvest rates in conjunction with the current estimated total harvest to track abundance as well as the harvest potential of the recreational fishery. These estimates, when used in conjunction with the migratory timing statistics from the historical weir counts, have allowed fishery managers to project the final escapement by accounting for the potential harvest while charting the escapement based upon past returns (Vincent-Lang and Carlon 1991).

A direct expansion creel survey was utilized during the 1996 season. The 1996 season was the seventh year that the direct expansion survey design has been applied to the Russian River sockeye salmon sport fishery. Previous concerns with biased harvest and effort estimates (Carlon and Vincent-Lang 1990) obtained with a stratified roving creel design (Neuhold and Lu 1957) necessitated a change in creel design beginning with the 1990 season.

Sampling was stratified by access location to estimate harvest and effort for anglers exiting the fishery at each of three sampled access locations. The temporal stratification used to estimate harvest and effort corresponded with the temporal strata for biological sampling of the confluence and river recreational harvest. Differences in age composition of the recreational harvest and the spawning escapement over time was evidenced in the three sampled areas of the fishery; the confluence, the river and the weir. Therefore, the data were poststratified by time. A survey stratum was thus defined as an access location/temporal component combination. The sampled locations included the ferry access to the confluence area and two river trails from the Grayling and Pink Salmon parking areas. These locations were sampled over two temporal components: from 11 June to 29 June and from 30 June to 20 July. Area-specific (river or confluence-area) harvest and effort were estimated for each stratum by recording the area fished for each interviewed angler.

The creel survey sampling day was 18 hours in length (0600 to 2400 hours) and was divided into six, 3-hour periods. A three-stage sampling design was used with days as primary units, periods as secondary units, and anglers as tertiary units. Days were systematically sampled, and within each sampled day, two 3-hour periods were randomly selected from the six possible periods. During each sampled period, anglers were interviewed as they exited the fishery through a sampled location. Thus, all interviews were of completed-trip anglers. All anglers exiting an access location during a sampled period were counted and as many as possible were interviewed for harvest and effort data by area fished (river or confluence area). Anglers exiting a location during a sampled period and not interviewed were prorated as river or confluence anglers based on proportions determined from anglers that were interviewed. Count and interview data were then expanded for each stratum to account for area-specific harvest and effort during periods and days that were not sampled.

During the years 1990 through 1992, approximately two-thirds of the harvest and effort occurred in the confluence area (Carlon et al. 1991, Marsh 1992-1993). Historically, this has been typical of the early-run sport fishery in most years (Nelson et al. 1986). As a result of this concentration of harvest and effort, and because harvest rate (harvest per hour) is used as a management tool to index sockeye salmon abundance at the confluence, the confluence access location (the ferry) was

sampled every other day throughout the early run. This ensured that timely information regarding confluence harvest rates was available when formulating inseason management strategies.

Creel survey results from the 1990 and 1991 seasons indicated that angler use patterns differed among the access locations to the sport fishery as well (Carlon et al. 1991, Marsh 1992). Three access locations, the ferry, Grayling and Pink Salmon, represented more than 90% of the total effort and more than 90% of the total harvest during the annual sport fishery. These locations also contributed approximately 90% of the total variance for both the harvest and effort estimates. Therefore, to better utilize creel survey personnel and improve the precision of the estimates of harvest and effort from the remaining access locations, Rainbow and Red Salmon were dropped from the sampling schedule beginning with the 1992 season. This sampling regime was continued during the 1996 season.

Estimates of effort, harvest, and their variances for the early run in 1990-1995 were used to optimally allocate the number of sampling days among the river access locations (Cochran 1977). In 1996, the ferry was sampled every other day, while Grayling was sampled approximately every 2 days and Pink Salmon sampled approximately every 3 days.

Angler effort and harvest were estimated for a stratified, three-stage (day/period/angler) direct expansion creel survey (Bernard et al. *In prep*). Total effort, harvest, and their variances were estimated for the entire run by summing the stratum (access location) estimates. In addition, the estimates were post-stratified by area fished (river or confluence) and by temporal strata within the run.

At access location k on day i during sample period j, m_{kij} represents those completed-trip anglers interviewed as they exited through location k and a_{kij} represents those anglers that exited and were counted but were not interviewed. Interviewed anglers were assigned to one of three groups:

m_{1kij} = anglers that fished the river area only,

m_{2kij} = anglers that fished the confluence area only, or

m_{3kij} = anglers that fished both areas, and

$$m_{kij} = m_{1kij} + m_{2kij} + m_{3kij}. \quad (1)$$

Area-specific harvest of missed anglers (a_{kij}) was prorated based on information obtained in interviews. The proportion of missed anglers that fished the river was estimated as:

$$\hat{P}_{rkij} = \frac{m_{rkij}}{m_{kij}}, \quad (2)$$

where:

m_{rkij} = the number of interviewed anglers fishing the river,

= $m_{1kij} + m_{3kij}$.

The number of missed anglers prorated as fishing the river ($\hat{a}_{rkij}$) was estimated as:

$$\hat{a}_{rkij} = a_{kij}\hat{P}_{rkij} \quad . \quad (3)$$

The total number of anglers fishing the river area and exiting the fishery at location k on day i during sample period j was estimated as:

$$\hat{M}_{rkij} = m_{rkij} + \hat{a}_{rkij} \quad . \quad (4)$$

The same procedure was used to prorate the missed anglers who fished the confluence area:

$$\hat{M}_{ckij} = m_{ckij} + \hat{a}_{ckij} \quad . \quad (5)$$

The mean river-area harvest per interviewed angler was estimated as:

$$\bar{h}_{rkij} = \frac{\sum_{i=1}^{m_{rkij}} h_{rkijl}}{m_{rkij}}, \quad (6)$$

where:

h_{rkijl} = the river-area harvest of angler l at location k on day i during sample period j.

The variance of river-area harvest among interviewed anglers was estimated assuming a normal variate as:

$$Var\left(\bar{h}_{rkij}\right) = \frac{\sum_{i=1}^{m_{rkij}} \left(h_{rkijl} - \bar{h}_{rkij}\right)^2}{m_{rkij} - 1} . \quad (7)$$

The total river-area harvest of anglers exiting through access location k on day i during sample period j was estimated as:

$$\hat{H}_{rkij} = \hat{M}_{rkij} \bar{h}_{rkij} . \quad (8)$$

The mean river-area harvest per period was then estimated for location k on day i as:

$$\bar{H}_{rki} = \frac{\sum_{j=1}^{u_{ki}} \hat{H}_{rkij}}{u_{ki}} , \quad (9)$$

where:

u_{ki} = the number of sample periods on day i ($u_{ki} = 2$),

and the variance among sample periods was estimated as:

$$Var\left(\bar{H}_{rki}\right) = \frac{\sum_{j=1}^{u_{ki}} \left(\hat{H}_{rkij} - \bar{H}_{rki}\right)^2}{u_{ki} - 1} . \quad (10)$$

The total river-area harvest of anglers exiting through access location k on day i was estimated by expanding the mean river-area harvest per period on day i by:

$$\hat{H}_{rki} = U_{ki} \bar{H}_{rki} , \quad (11)$$

where:

U_{ki} = the total number of periods on a day ($U_{ki} = 6$).

The mean river-area harvest per day was estimated at location k as:

$$\bar{H}_{rk} = \frac{\sum_{i=1}^{d_k} \hat{H}_{rki}}{d_k} , \quad (12)$$

where:

d_k = the number of days sampled.

The variance of river-area harvest among days at location k was estimated using the variance for a systematic sample as:

$$Var\left(\bar{H}_{rk}\right) = \frac{\sum_{i=2}^{d_k} \left(\hat{H}_{rki} - \hat{H}_{rk(i-1)}\right)^2}{2\left(d_k - 1\right)} . \quad (13)$$

The total river-area harvest at location k was estimated by expanding the mean harvest per day by:

$$\hat{H}_{rk} = D_k \bar{H}_{rk} , \quad (14)$$

where:

D_k = the total number of days during the run.

The variance of the total river-area harvest at location k was estimated as:

$$Var\left(\hat{H}_{rk}\right) = \left(1 - f_1\right) D_k^2 \frac{Var\left(\bar{H}_{rk}\right)}{d_k} + D_k \frac{U_{ki}^2}{u_{ki}} \left(1 - f_2\right) \frac{\sum_{i=1}^{d_k} Var\left(\bar{H}_{rki}\right)}{d_k} + D_k U_{ki} \sum_{i=1}^{d_k} \sum_{j=1}^{u_{ki}} M_{rkij}^2 \left(1 - f_3\right) \frac{Var\left(\bar{h}_{rkij}\right)}{d_k u_{ki} m_{rkij}} , \quad (15)$$

where:

D_k = the total number of sampling days at location k during the run,

f_1 = the finite population correction factor for days (d_k/D_k),

f_2 = the finite population correction factor for periods (u_{ki}/U_{ki}), and

f_3 = the finite population correction factor for anglers (m_{rkij}/M_{rkij}).

These procedures (Equations 2 through 15) were also used to estimate the confluence-area harvest of anglers exiting through each access location. Likewise, the same procedures were used to estimate effort (in angler-hours) expended in the river area and the confluence area by substituting the area-specific hours of effort reported by interviewed anglers for the reported harvest in Equations 2 through 15.

Total harvest and effort were estimated for the run by summing the individual stratum estimates. The variances of the total estimates were calculated as the sum of the variances of the individual stratum estimates.

Daily harvest rates were estimated and used for inseason management as an indicator of sockeye salmon abundance. Regardless of access location, the daily confluence-area harvest rate was based solely on confluence effort and the resultant harvest reported by interviewed anglers. The mean daily harvest rate of the confluence area was estimated as:

$$\overline{HPUE}_{ci} = \frac{\sum_{l=1}^{m_{ci}} HPUE_{cil}}{n_c}, \qquad (16)$$

where:

m_{ci} = number of interviewed anglers reporting confluence-area effort, and

$HPUE_{cl}$ = confluence-area harvest per hour of effort for angler l.

The variance of this estimate was calculated as:

$$Var\left(\overline{HPUE}_{ci}\right) = \frac{\sum_{l=1}^{n_c} \left(HPUE_{cl} - \overline{HPUE}_c\right)^2}{m_{ci}\left(m_{ci} - 1\right)}. \qquad (17)$$

The same procedure was used to estimate river-area harvest rates.

The overall harvest rate for the early run provides a relative basis for comparing seasonal fishing success among years (Nelson 1985, Hammarstrom and Athons 1988). A harvest rate for the early run was estimated by dividing the total harvest estimate by the total effort estimate. The associated variance was then calculated as the variance of a quotient of two random variables. The same procedure was applied to estimate the harvest rate within each spatial component of the recreational fishery (confluence and river).

Spawning Escapement

The escapement of spawning sockeye salmon to the Russian River drainage was enumerated at the stationary weir at the outlet of Lower Russian Lake. An adjustable gate system allowed fish to be passed individually and counted by the weir operator. During the period of overlap of early and late runs (mid to late July), fish from each run were subjectively identified by degree of external sexual maturation (body color and kype development) and counted separately. Early in each run, adults have not yet developed the red body coloration and green head with distended, hooked jaws characteristic of more sexually mature fish which pass through the weir later in each run. Therefore, during the period of run overlap at the weir, the last of the early-run fish typically exhibit the reddish body coloration and green heads while the late-run fish have not yet developed these physical characteristics. The period of overlap began on 16 July when late-run fish were intermixed with mature, early-run fish

and continued through 25 July, after which early-run fish were no longer present.

Biological Data

Six time and area strata within the Russian River sockeye salmon return were sampled for biological data to estimate the age, sex, and length composition of the early run (Table 1).

Table 1.-Temporal components of the recreational harvest and escapement sampled for age composition during the 1996 early-run Russian River sockeye salmon return.

Return Component	Temporal Strata
Confluence-area harvest	6/11 - 6/29
	6/30 - 7/20
River-area harvest	6/11 - 6/29
	6/30 - 7/20
Escapement through weir	6/11 - 6/29
	6/30 - 7/20

The sampling strata corresponded to those for which harvest was estimated by the creel survey. Schedules of each creel survey clerk allowed for biological sampling of the harvest at least part of each day that angler interviews were conducted. In addition, several days of biological sampling without creel interviews were scheduled for one or both creel clerks when fishing effort and harvest were the greatest.

Scales were collected from the preferred area of each sampled fish and placed on adhesive-coated cards (Clutter and Whitesel 1956). The sex and length (measured from the mid-eye to the fork-of-tail to the nearest millimeter) of each sampled fish were also determined and recorded. Scale impressions were made in clear acetate and examined with a microfiche reader for aging. The European method of age description was used to record ages: the numeral preceding the decimal represents the number of freshwater annuli and the numeral following the decimal represents the number of marine annuli. Total age from brood is therefore the sum of the two numbers plus one.

Age and sex composition of the run was estimated for each stratum. The proportion of fish of age group g in stratum f was estimated as:

$$\hat{p}_{gf} = \frac{x_{gf}}{n_f}, \tag{18}$$

where:

x_{gf} = the number of legible scales read from sockeye salmon sampled during stratum f and interpreted as age g, and

n_f = the total number of legible scales read from sockeye salmon sampled during stratum f.

The variance of this proportion was estimated as (Scheaffer et al. 1979):

$$\mathrm{Var}\left(\hat{p}_{gf}\right) = \frac{\hat{p}_{gf}\left(1-\hat{p}_{gf}\right)}{n_f - 1}. \tag{19}$$

The age composition by sex of the harvest within each stratum was estimated by:

$$\hat{H}_{gf} = \hat{H}_f \hat{p}_{gf}, \tag{20}$$

where:

$\hat{H}_f$ = the estimated total harvest of sockeye salmon during stratum f.

The variance of the age composition was estimated as the product of two independent random variables (Goodman 1960):

$$\mathrm{Var}\left(\hat{H}_{gf}\right) = \hat{H}_f^2 \mathrm{Var}\left(\hat{p}_{gf}\right) +$$

$$\hat{p}_{gf}^2 \, Var\left(\hat{H}_f\right) - Var\left(\hat{p}_{gf}\right) Var\left(\hat{H}_f\right) , \quad (21)$$

where:

$Var\left(\hat{H}_f\right)$ = the variance of the harvest estimate during stratum f.

Age composition of the total harvest from the confluence and total harvest from the river were estimated by sex by summing the age composition estimates among the temporal strata. The total number of fish of age g in the harvest from the river was estimated as:

$$\hat{H}_{rg} = \sum_{f=1}^{t} \hat{H}_{rgf} , \quad (22)$$

where:

t = the number of strata in the run.

The variance of the estimate was calculated by summing the variances of the individual temporal stratum estimates as:

$$Var\left(\hat{H}_{rg}\right) = \sum_{f=1}^{t} Var\left(\hat{H}_{rgf}\right). \quad (23)$$

The proportion of sockeye salmon of age g in the total sport harvest from the river was estimated as:

$$\hat{p}_{rg} = \frac{\hat{H}_{rg}}{\hat{H}_r}, \quad (24)$$

where:

$\hat{H}_r$ = the estimated total harvest of sockeye salmon from the river.

The variance of this proportion was estimated as an approximation using the delta method (Seber 1982:7-8) as:

$$Var\left(\hat{p}_{rg}\right) \approx \frac{1}{\hat{H}_r^2} \left\{ \frac{Var\left(\hat{H}_{r1}\right)\left[\hat{H}_r \hat{p}_{rg1} - \hat{H}_{rg}\right]^2}{\hat{H}_r^2} + Var\left(\hat{p}_{rg1}\right)\hat{H}_{r1}^2 + Var\left(\hat{p}_{rg2}\right)\hat{H}_{r2} \right\}, \quad (25)$$

where:

$\hat{H}_{rf}$ and $Var\left(\hat{H}_{rf}\right)$ = the estimates of harvest and variance of harvest from the river during temporal stratum f,

$\hat{p}_{rgf}$ and $Var\left(\hat{p}_{rgf}\right)$ = the estimates of proportion and variance of proportion of fish of age g sampled from the harvest from the river during temporal stratum f, and

$\hat{H}_{rgf}$ = the estimated harvest of fish of age g from the river during temporal stratum f.

This proportion and its variance were estimated similarly for the harvest of sockeye salmon from the confluence. Note that the value of temporal stratum f (= 1 or 2) appears in the equation (25).

The number of sockeye salmon of age group g of stratum f in the escapement was estimated by sex using the estimates of the age group proportions defined previously:

$$\hat{E}_{gf} = E_f \hat{p}_{gf}, \quad (26)$$

where:

E_f = the total number of sockeye salmon enumerated during stratum f at the weir or spawning downstream from the falls.

The variance of $\hat{E}_{gf}$ was estimated as:

$$Var\left(\hat{E}_{gf}\right) = E_f^2 \, Var\left(\hat{p}_{gf}\right) . \quad (27)$$

The age composition of the entire escapement past the weir was estimated by summing the stratum estimates. The total number of fish of age g migrating through the weir was estimated as:

$$\hat{E}_g = \sum_{f=1}^{t} \hat{E}_{gf} \quad . \tag{28}$$

Similarly, the variance was estimated as the sum of the variances as:

$$\mathrm{Var}\left(\hat{E}_g\right) = \sum_{f=1}^{t} \hat{E}_{gf}. \tag{29}$$

The proportion of sockeye salmon of age g in the total escapement migrating through the weir was estimated as:

$$\hat{p}_{eg} = \frac{\hat{E}_g}{E_T}, \tag{30}$$

where:

E_T = the total escapement enumerated at the weir.

The variance of this proportion was estimated by:

$$\mathrm{Var}\left(\hat{p}_{eg}\right) = \frac{\mathrm{Var}\left(\hat{E}_g\right)}{E_T^2}. \tag{31}$$

The total return, total return by age, and their respective variances were estimated by summing the estimates from the total harvest at the confluence and at the river, and from the escapement. The proportion of sockeye salmon of age g in the total return was estimated as:

$$\hat{p}_g = \frac{\hat{N}_g}{\hat{N}_T}, \tag{32}$$

where:

$\hat{N}_g$ = the estimated total return of fish of age g, and

$\hat{N}_T$ = the estimate of the total return.

The variance of this proportion was estimated as an approximation using the delta method (Seber 1982:7-8) as:

$$\begin{aligned}\mathrm{Var}\left(\hat{P}_g\right) \approx \\ \frac{1}{\hat{N}_T^2}\Bigg\{ & \frac{\mathrm{Var}\left(\hat{H}_c\right)\left[\hat{p}_{cg}\left(\hat{H}_r + E\right) - \left(\hat{H}_{rg} + \hat{E}_g\right)\right]^2}{\hat{N}_T^2} \\ & + \frac{\mathrm{Var}\left(\hat{H}_r\right)\left[\hat{p}_{rg}\left(\hat{H}_c + E\right) - \left(\hat{H}_{cg} + \hat{E}_g\right)\right]^2}{\hat{N}_T^2} \\ & + \mathrm{Var}\left(\hat{p}_{cg}\right)\hat{H}_c^2 + \mathrm{Var}\left(\hat{p}_{rg}\right)\hat{H}_r^2 \\ & + \mathrm{Var}\left(\hat{p}_{eg}\right)E^2\Bigg\},\end{aligned} \tag{33}$$

where:

$\hat{H}_\bullet$ and $\mathrm{Var}\left(\hat{H}_\bullet\right)$ = the estimates of total harvest and variance of total harvest from the river (= r) or the confluence (= c), and

$\hat{p}_{\bullet g}$ and $\mathrm{Var}\left(\hat{p}_{\bullet g}\right)$ = the estimates of proportion and variance of proportion of fish of age g from the total harvest from the river (= r) or the confluence, or from the escapement (= e).

In prior years, the age composition of the early-run escapement was used to estimate the return by age for both the escapement and early-run harvest at both the confluence and river areas (Nelson et al. 1986, Carlon and Vincent-Lang 1990). This assumed that the age composition of the escapement through the weir represented that of the river and confluence-area sport harvests. This assumption was initially tested in both 1990 and 1991. Significant differences in age compositions were found among the three sampled areas during some of the temporal strata (Carlon et al. 1991, Marsh 1992). Chi-square tests were used to test the null hypotheses that the age distributions were equal among the three areas and between the two temporal strata. The null hypothesis was

rejected if calculated tail-area probabilities were less than 0.05. Failure to reject the null hypothesis would allow the age samples to be pooled to achieve a more precise estimate of the number of sockeye salmon by age in the harvest and escapement.

Mean length at age was estimated for each temporal stratum within each of three spatial strata of the return: the confluence-area harvest, the river harvest, and the weir escapement. Associated variances were estimated using standard normal procedures. An analysis of variance (ANOVA) was used to determine if mean length at age differed by area, temporal strata, and sex. This analysis was conducted for the predominant age groups (age-2.3, -1.3 and -2.2 fish). This analysis was not conducted for age 1.2 due to insufficient samples.

RESULTS

CREEL STATISTICS

Survey Interviews

Sampling began on 11 June 1996 at the ferry access location and continued every other day through the end of the early run on 20 July 1996. The systematic sampling of the two Russian River Campground access locations began on 15 June, 4 days after sampling commenced at the ferry location. Because early-run sockeye salmon typically hold in the confluence area before entering the Russian River, harvest and effort are considered negligible until approximately the third week in June. Onsite observations and creel data indicated that during the 1996 early run, effort and the resulting harvest began significantly earlier than normal with notable catches evidenced on 13 June.

A total of 7,121 anglers were enumerated as they exited sampled access locations during the 1996 early-run creel survey (Table 2). Of these, 6,743 (95%) were interviewed and 378 (5%) were not interviewed. While the level of creel sampling remains similar to the first year (1990) that the 3-stage direct expansion survey was implemented (Carlon et al. 1991), the total number of interviews collected in 1996 represents an 85% increase from 1995. Most of the interviews (73.0%) were made at the ferry access, as this location was sampled the most intensely. This area typically accounts for most of the sport fishing effort (Appendix A1). Anglers exiting via the ferry location tended to fish the confluence area (96%) (Appendix A2).

Harvest and Effort

Estimates of harvest, effort, and variances are presented by stratum (temporal period/access location) in Appendix A3. By examining stratum estimates and the associated variance components by access location, it is possible to determine which access locations most affected the relative precision of early-run estimates of both harvest and effort (Table 3). Of the three access locations, (the ferry, Grayling, and Pink Salmon), the ferry accounted for most of the effort and harvest during the early run (59% and 62%, respectively). The relative precisions of the early-run harvest and effort estimates were 30% and 17%, respectively (Table 3). The 1996 early-run harvest estimate was 75,203 (SE = 11,342) sockeye salmon (Table 4). The effort estimate for the early run was 225,457 (SE = 19,848) angler-hours. During the early run, 77% of the harvest was taken from the confluence area and the remaining 23% was taken from the river area (Table 4 and Figure 4).

Harvest per hour of angler effort was 0.320 fish (V = 0.0018) for the confluence area and 0.386 (V = 0.0348) for the river area in 1996 (Table 5).

Table 2.-Summary of the number of interviews collected during sampled periods for the early-run Russian River creel survey, 1996.

Exit Location	Area Fished			Total Interviews	Anglers Exiting and Not Interviewed	Total Anglers Exiting
	Confluence	River	Both			
Ferry	4,687	181	50	4,918	312	5,230
Grayling	722	550	94	1,366	37	1,403
Pink Salmon	148	268	43	459	29	488
Total	5,557	999	187	6,743	378	7,121

Table 3.-Estimates of harvest, effort, and associated variances by access location for the early-run Russian River sockeye salmon recreational fishery, 1996.

Access Location	Harvest	(%)	Variance of Harvest	(%)	Relative Precision[a]	Effort[b]	(%)	Variance of Effort	(%)	Relative Precision[a]
Ferry	46,589	62	36,693,323	29	25%	133,684	59	120,993,506	31	16%
Grayling	20,332	27	47,581,557	37	66%	61,056	27	182,067,166	46	43%
Pink Salmon	8,282	11	44,367,880	34	158%	30,717	14	90,865,500	23	61%
Total	75,203	100	128,642,760	100	30%	225,457	100	393,926,172	100	17%

[a] $\alpha = 0.05$

[b] Angler hours.

Table 4.-Summary of estimated angler effort and harvest by component during the early run of Russian River sockeye salmon, 1996.

Component	Confluence Area	River Area	Total	95% Confidence Interval
Effort[a]	180,115	45,342	225,457	186,556 - 264,358
SE	16,688	10,744	19,848	
Harvest	57,688	17,515	75,203	52,973 - 97,433
SE	7,560	8,455	11,342	

[a] Angler-hours.

Table 5.-Estimated harvest per hour of angler effort (HPUE) by anglers interviewed during the early run of the Russian River sockeye salmon recreational fishery, 1996.

Area	Days n[a]	Days N[b]	Number of Interviews[c]	HPUE	Variance of HPUE
Confluence	32	40	5,744	0.320	0.0018
River	28	35	1,186	0.386	0.0348
Both			6,930	0.334	0.0025

[a] Number of days on which at least one angler reported fishing effort.

[b] Number of days possible for conducting interviews.

[c] Anglers who fished both areas are represented twice.

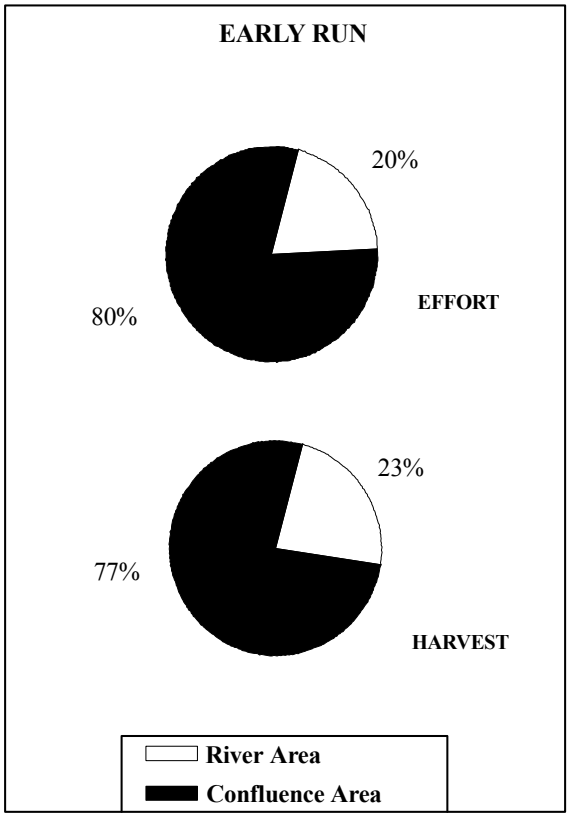

Figure 4.-Harvest and angler effort by area for the Russian River early-run sockeye salmon recreational fishery, 1996.

SPAWNING ESCAPEMENT

A total of 52,905 early-run sockeye salmon passed through the weir (Figure 5 and Appendix A4). Late-run sockeye salmon began arriving on 16 July and the last early-run fish was passed on 25 July.

BIOLOGICAL DATA

Chi-square tests detected significant differences between all of the three spatial strata (confluence-area harvest, river-area harvest, and weir escapement) during at least one of the temporal strata (Table 6). The age composition of the weir escapement differed from that of the confluence-area harvest and from the river-area harvest during both temporal strata (Table 6). The age composition of the confluence-area harvest was significantly different from that of the river-area harvest during the first sampling strata but no significant differences were detected during the second temporal strata (Table 6).

Chi-square tests also indicated that age composition was significantly different over time for all sampled locations (Table 7).

Because the age composition of the weir escapement differed significantly over time, the estimate of the number of sockeye salmon by age in the weir escapement was stratified by temporal strata (Table 8). In addition, because Chi-square tests indicated that the age composition of both harvest locations was significantly different over time, the estimates of the number of sockeye salmon from the river-area harvest as well as the confluence-area harvest were stratified by temporal strata in order to generate an estimate of the number of sockeye salmon by age in the recreational harvest (Tables 9 and 10). Estimates for each spatial/temporal strata were summed to estimate the age composition of the total return (Table 11).

The early-run escapement comprised predominantly age groups 2.3, 2.2 and 1.3 (Table 8). A fourth age group, age 1.2, made up less than 1% of the escapement with the predominant age group (58%) being age 2.3. There was a significant difference ($\chi^2 = 26.58$, df = 1, P = 0.0000003) in the relative proportions of age-2.3 and -2.2 adults between the two temporal strata at the weir.

The early-run recreational harvest from the samples obtained from the confluence area comprised primarily age-2.3 and 1.3 adults (48%) and (45%), respectively (Table 9). The river-area harvest comprised predominantly age-2.3 adults (73%), with age-1.3 and age-2.2 contributing similar proportions of 14% and 13%, respectively (Table 10).

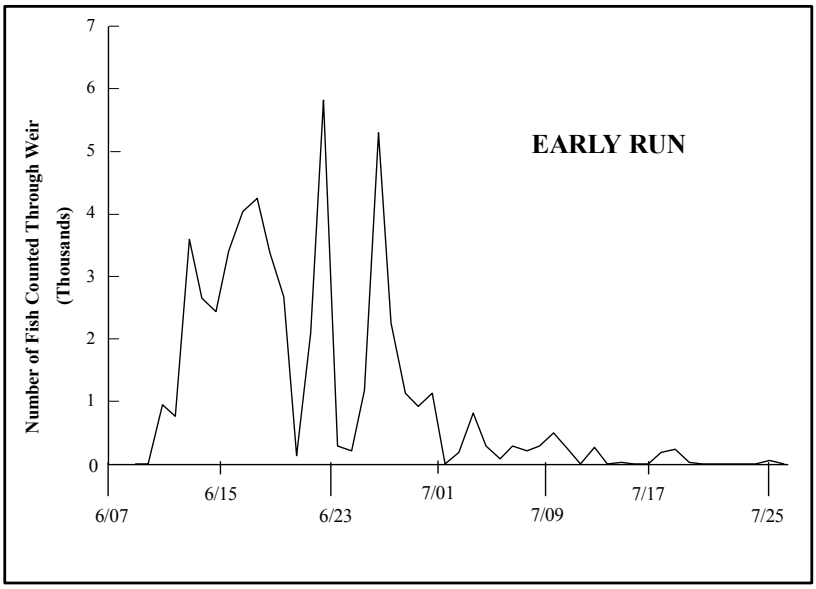

Figure 5.-Daily escapement of sockeye salmon through the Russian River weir during the early run, 1996.

Table 6.-Results of contingency test comparisons of age composition between spatial fishery components for the early-run Russian River sockeye salmon recreational fishery, 1996.

	Spatial Component		
Temporal Stratum[a]	Confluence Harvest vs. River Harvest	Confluence Harvest vs. Weir Escapement	River Harvest vs. Weir Escapement
1	df = 2, X^2 = 60.90, P = 0.0000000 S[b] (P < 0.05)	df = 2, X^2 = 48.61, P = 0.0000000 S[b] (P < 0.05)	df = 2, X^2 = 10.34, P = 0.0057 S[b] (P < 0.05)
2	df = 2, X^2 = 5.27, P = 0.072 NS[b] (P > 0.05)	df = 2, X^2 = 33.97, P = 0.0000000 S[b] (P < 0.05)	df = 2, X^2 = 24.36, P = 0.0000051 S[b] (P < 0.05)

[a] 1 = 6/11-6/29.
2 = 6/30-7/20 (6/30-7/25 for weir escapement).

[b] NS = No significant difference, S = significant difference.

Table 7.-Results of contingency test comparisons of age composition between temporal fishery components for the early-run Russian River sockeye salmon recreational fishery, 1996.

Spatial Component	Temporal Component: 11 June to 29 June	vs.	30 June to 20 July[a]
Confluence Harvest	$df = 2, X^2 = 42.18, P = 0.0000000$ Significant, $P < 0.05$		
River Harvest	$df = 2, X^2 = 9.83, P = 0.007$ Significant, $P < 0.05$		
Weir Escapement	$df = 2, X^2 = 26.50, P = 0.0000017$ Significant, $P < 0.05$		

[a] 6/30-7/25 for weir escapement.

There were significant differences in length-at-age among areas for two of the three dominant age classes which were represented in the return: age-2.3 fish ($F = 6.03$; $df = 2, 536$; $P = 0.003$) and age-2.2 fish ($F = 32.34$; $df = 2, 252$; $P = 0.0001$). In addition, there were significant differences in length-at-age detected between the sex of sampled age-2.3 fish ($F = 7.17$; $df = 1, 536$; $P = 0.007$) (Table 11)

TOTAL RETURN STATISTICS

Overall, an estimated 128,108 early-run sockeye salmon returned to the Russian River in 1996 (Table 12). Brood years 1990 (age 2.3) and 1991 (age 2.3 and 1.3) were both significant contributors to the early-run return. However, age-2.3 fish comprised the majority of the return (56%). The brood year 1991 contributed 44% to the early-run return, with the 1992 (age 1.2) brood year comprising just 0.7% of the return. The 1990 escapement of approximately 25,000 spawners produced approximately 95,000 returning adults (Table 13).

APPLICATION OF THE DATA FOR FISHERY MANAGEMENT

Both the early and late sockeye salmon runs are managed for escapement. Based on analyses of brood production data (Carlon and Vincent-Lang 1990), a sockeye salmon escapement goal of 16,000 was established by the Board of Fisheries during their 1989 forum.

On Friday, 14 June 1996, a total of 13,917 sockeye salmon had migrated through the weir with an estimated 1,000 fish holding immediately downstream from the weir. An additional 1,000 fish were estimated to be holding in the falls area of the river. Observations of the sport fishery in conjunction with harvest data indicated that the sport fishery was quite strong and was

Table 8.-Estimated age and sex composition of the early-run sockeye salmon escapement through the Russian River weir, 1996.

Dates	Age Group 2.3	1.3	2.2	2.1	1.2	Total
6/11 - 6/29						
n[a]= 95						
Count= 48,877						
Females						
Sample Size	21	8	7	0	0	36
Percent	22.1	8.4	7.4	0.0	0.0	37.9
Variance of Percent	18.3	8.2	7.3	0.0	0.0	25.0
Number	10,804	4,116	3,601	0	0	18,522
Variance of Number	4,376,078	1,959,942	1,734,661	0	0	5,981,203
Males						
Sample Size	36	8	15	0	0	59
Percent	37.9	8.4	15.8	0.0	0.0	62.1
Variance of Percent	25.0	8.2	14.1	0.0	0.0	25.0
Number	18,522	4,116	7,717	0	0	30,355
Variance of Number	5,981,203	1,959,942	3,379,211	0	0	5,981,203
Sexes Combined						
Sample Size	57	16	22	0	0	95
Percent	60.0	16.8	23.2	0.0	0.0	100.0
Variance of Percent	25.5	14.9	18.9	0.0	0.0	
Number	29,326	8,232	11,319	0	0	48,877
Variance of Number	6,099,475	3,559,435	4,522,510	0	0	

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Table 8.-Page 2 of 3.

Dates		Age Group 2.3	1.3	2.2	2.1	1.2	Total
6/30 - 7/25							
n[a]=	341						
Count=	4,028						
Females							
Sample Size		53	26	98	0	3	180
Percent		15.5	7.6	28.7	0.0	0.9	52.8
Variance of Percent		3.9	2.1	6.0	0.0	0.3	7.3
Number		626	307	1,158	0	35	2,126
Variance of Number		6,264	3,361	9,773	0	416	11,893
Males							
Sample Size		61	16	80	0	4	161
Percent		17.9	4.7	23.5	0.0	1.2	47.2
Variance of Percent		4.3	1.3	5.3	0.0	0.3	7.3
Number		721	189	945	0	47	1,902
Variance of Number		7,009	2,134	8,569	0	553	11,893
Sexes Combined							
Sample Size		114	42	178	0	7	341
Percent		33.4	12.3	52.2	0.0	2.1	100.0
Variance of Percent		6.5	3.2	7.3	0.0	0.6	
Number		1,347	496	2,103	0	83	4,028
Variance of Number		10,620	5,154	11,907	0	959	

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Table 8.-Page 3 of 3.

Dates	Age Group 2.3	1.3	2.2	2.1	1.2	Total
Early Run Total						
n[a]= 436						
Count= 52,905						
Females						
Percent	21.6	8.4	9.0	0.0	0.1	39.0
Variance of Percent	15.7	7.0	6.2	0.0	0.0	21.4
Number	11,430	4,423	4,759	0	35	20,648
Variance of Number	4,382,342	1,963,303	1,744,434	0	416	5,993,096
Males						
Percent	36.4	8.1	16.4	0.0	0.1	61.0
Variance of Percent	21.4	7.0	12.1	0.0	0.0	21.4
Number	19,242	4,305	8,662	0	47	32,257
Variance of Number	5,988,212	1,962,076	3,387,779	0	553	5,993,096
Sexes Combined						
Percent	58.0	16.5	25.4	0.0	0.2	100.0
Variance of Percent	21.8	12.7	16.2	0.0	0.0	
Number	30,673	8,728	13,421	0	83	52,905
Variance of Number	6,110,095	3,564,589	4,534,417	0	959	

[a] n = sample size.

Table 9.-Estimated age and sex composition of early-run sockeye salmon harvested in the confluence area of the Russian River recreational fishery, 1996.

Dates	Age Group 2.3	1.3	2.2	2.1	1.2	Total
6/11 - 6/29						
n[a]= 212						
Harvest= 50,058						
Var(Harvest)= 54,946,674						
Females						
Sample Size	54	44	6	0	3	107
Percent	25.5	20.8	2.8	0.0	1.4	50.5
Variance of Percent	9.0	7.8	1.3	0.0	0.7	11.8
Number	12,751	10,389	1,417	0	708	25,265
Variance of Number	5,770,011	4,277,280	363,447	0	173,046	16,900,674
Males						
Sample Size	46	59	0	0	0	105
Percent	21.7	27.8	0.0	0.0	0.0	49.5
Variance of Percent	8.1	9.5	0.0	0.0	0.0	11.8
Number	10,862	13,931	0	0	0	24,793
Variance of Number	4,560,400	6,588,686	0	0	0	16,382,309
Sexes Combined						
Sample Size	100	103	6	0	3	212
Percent	47.2	48.6	2.8	0.0	1.4	100.0
Variance of Percent	11.8	11.8	1.3	0.0	0.7	
Number	23,612	24,321	1,417	0	708	50,058
Variance of Number	15,120,141	15,871,657	363,447	0	173,046	54,946,674

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Table 9.-Page 2 of 3.

Dates		Age Group 2.3	1.3	2.2	2.1	1.2	Total
6/30 - 7/20							
n^a=	119						
Harvest=	7,630						
Var(Harvest)=	2,204,520						
Females							
Sample Size		34	14	23	0	0	71
Percent		28.6	11.8	19.3	0.0	0.0	59.7
Variance of Percent		17.3	8.8	13.2	0.0	0.0	20.4
Number		2,180	898	1,475	0	0	4,552
Variance of Number		276,835	79,787	156,365	0	0	898,997
Males							
Sample Size		34	12	2	0	0	48
Percent		28.6	10.1	1.7	0.0	0.0	40.3
Variance of Percent		17.3	7.7	1.4	0.0	0.0	20.4
Number		2,180	769	128	0	0	3,078
Variance of Number		276,835	65,457	8,466	0	0	472,913
Sexes Combined							
Sample Size		68	26	25	0	0	119
Percent		57.1	21.8	21.0	0.0	0.0	100.0
Variance of Percent		20.8	14.5	14.1	0.0	0.0	
Number		4,360	1,667	1,603	0	0	7,630
Variance of Number		836,092	186,289	176,070	0	0	2,204,520

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Table 9.-Page 3 of 3.

Dates	Age Group					
	2.3	1.3	2.2	2.1	1.2	Total
Early Run Total						
n[a]= 331						
Harvest= 57,688						
Var(Harvest)= 57,151,194						
Females						
Percent	25.9	19.6	5.0	0.0	1.2	51.7
Variance of Percent	7.1	6.0	1.2	0.0	0.5	9.3
Number	14,931	11,287	2,891	0	708	29,817
Variance of Number	6,046,846	4,357,067	519,812	0	173,046	17,799,671
Males						
Percent	22.6	25.5	0.2	0.0	0.0	48.3
Variance of Percent	6.4	7.3	0.0	0.0	0.0	9.3
Number	13,042	14,701	128	0	0	27,871
Variance of Number	4,837,235	6,654,143	8,466	0	0	16,855,222
Sexes Combined						
Percent	48.5	45.0	5.2	0.0	1.2	100.0
Variance of Percent	9.3	9.2	1.2	0.0	0.5	0.0
Number	27,972	25,988	3,020	0	708	57,688
Variance of Number	15,956,232	16,057,946	539,517	0	173,046	57,151,194

[a] n = sample size.

Table 10.-Estimated age and sex composition of early-run sockeye salmon harvested in the river area of the Russian River recreational fishery, 1996.

Dates		Age Group 2.3	1.3	2.2	2.1	1.2	Total
6/11 - 6/29							
n[a]=	230						
Harvest=	14,341						
Var(Harvest)=	68,762,837						
Females							
Sample Size		71	13	12	0	1	97
Percent		30.9	5.7	5.2	0.0	0.4	42.2
Variance of Percent		9.3	2.3	2.2	0.0	0.2	10.6
Number		4,427	811	748	0	62	6,048
Variance of Number		6,680,194	251,557	216,744	0	3,888	12,376,220
Males							
Sample Size		99	22	11	0	1	133
Percent		43.0	9.6	4.8	0.0	0.4	57.8
Variance of Percent		10.7	3.8	2.0	0.0	0.2	10.6
Number		6,173	1,372	686	0	62	8,293
Variance of Number		12,886,536	680,848	184,508	0	3,888	23,139,099
Sexes Combined							
Sample Size		170	35	23	0	2	230
Percent		73.9	15.2	10.0	0.0	0.9	100.0
Variance of Percent		8.4	5.6	3.9	0.0	0.4	
Number		10,600	2,182	1,434	0	125	14,341
Variance of Number		37,681,357	1,669,463	741,432	0	10,353	68,762,837

-continued-

Table 10.-Page 2 of 3.

Dates		Age Group 2.3	1.3	2.2	2.1	1.2	Total
6/30 - 7/20							
n[a]=	61						
Harvest=	3,174						
Var(Harvest)=	2,728,729						
Females							
Sample Size		20	4	11	0	0	35
Percent		32.8	6.6	18.0	0.0	0.0	57.4
Variance of Percent		36.7	10.2	24.6	0.0	0.0	40.8
Number		1,041	208	572	0	0	1,821
Variance of Number		320,312	19,235	106,829	0	0	928,272
Males							
Sample Size		21	1	4	0	0	26
Percent		34.4	1.6	6.6	0.0	0.0	42.6
Variance of Percent		37.6	2.7	10.2	0.0	0.0	40.8
Number		1,093	52	208	0	0	1,353
Variance of Number		351,037	2,707	19,235	0	0	525,673
Sexes Combined							
Sample Size		41	5	15	0	0	61
Percent		67.2	8.2	24.6	0.0	0.0	100.0
Variance of Percent		36.7	12.5	30.9	0.0	0.0	
Number		2,133	260	780	0	0	3,174
Variance of Number		1,259,710	27,546	187,702	0	0	2,728,729

-continued-

Table 10.-Page 3 of 3.

Dates		Age Group 2.3	1.3	2.2	2.1	1.2	Total
Early Run Total							
n[a]=	291						
Harvest=	17,515						
Var(Harvest)=	71,491,566						
Females							
Percent		31.2	5.8	7.5	0.0	0.4	44.9
Variance of Percent		7.5	1.9	3.5	0.0	0.1	10.2
Number		5,468	1,019	1,321	0	62	7,869
Variance of Number		7,000,506	270,792	323,573	0	3,888	13,304,492
Males							
Percent		41.5	8.1	5.1	0.0	0.4	55.1
Variance of Percent		9.0	3.1	1.7	0.0	0.1	10.2
Number		7,266	1,424	894	0	62	9,646
Variance of Number		13,237,572	683,555	203,743	0	3,888	23,664,772
Sexes Combined							
Percent		72.7	13.9	12.6	0.0	0.7	100.0
Variance of Percent		7.2	4.6	5.2	0.0	0.3	0.0
Number		12,733	2,442	2,215	0	125	17,515
Variance of Number		38,941,067	1,697,009	929,134	0	10,353	71,491,566

[a] n = sample size.

Table 11.-Mean length (millimeters) at age, by sex, for the early run of sockeye salmon sampled from the Russian River, 1996.

			Age											
			2.3			2.2			1.3			1.2		
Date	Component	Sex	n	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE
6/11 - 6/29	Confluence	F	54	613	2.9	6	544	5.1	44	609	3.1	3	537	12.9
		M	46	614	3.7				59	612	2.9			
	River	F	71	606	2.6	12	552	5.3	13	606	7.9	1	495	
		M	99	615	2.5	11	549	7.2	22	616	7.0	1	510	
	Escapement[a]	F	21	594	5.9	7	601	9.7	8	598	8.6			
		M	36	904	4.6	15	596	7.1	8	604	8.8			
6/30 - 7/25	Confluence	F	34	600	3.7	23	549	2.7	14	593	7.0			
		M	34	601	3.5	2	536	6.0	12	601	6.9			
	River	F	20	598	4.1	11	547	4.9	4	616	8.9			
		M	21	602	3.7	4	550	7.3	1	631				
	Escapement	F	51	590	5.4	96	585	3.3	28	595	6.0			
		M	61	603	3.5	76	592	3.7	20	604	5.4			

[a] Fish sampled through the weir at the outlet of Lower Russian Lake.

Table 12.-Estimated age and sex composition of the early run of sockeye salmon to the Russian River, 1996.

Dates	Age Group 2.3	1.3	2.2	2.1	1.2	Total
6/11 - 7/20						
Early Run Total[a] n[b]= 1,049						
Females						
Percent	24.8	13.1	7.0	0.0	0.6	45.5
Variance of Percent	4.4	2.8	1.4	0.0	0.1	5.9
Number	31,829	16,729	8,971	0	806	58,335
Variance of Number	17,429,694	6,591,162	2,587,819	0	177,350	37,097,259
Males						
Percent	30.9	15.9	7.6	0.0	0.1	54.5
Variance of Percent	5.8	3.3	2.3	0.0	0.0	5.9
Number	39,550	20,429	9,685	0	110	46,558
Variance of Number	24,063,019	9,299,775	3,599,988	0	4,441	6,372,990
Sexes Combined						
Percent	55.7	29.0	14.6	0.0	0.7	100.0
Variance of Percent	7.2	6.0	3.4	0.0	0.1	0.0
Number	71,378	37,158	18,656	0	916	128,108
Variance of Number	61,007,395	21,319,544	6,003,068	0	184,359	128,642,760

[a] Confluence area harvest + river area harvest + escapement through the weir.

[b] n = sample size.

Table 13.-Summary of returns from each brood year, early-run Russian River sockeye salmon, 1974-1996.

Year	Spawning Escapement	Return Age 1.2	Age 2.1	Age 1.3	Age 2.2	Age 2.3	(1.1,1.4) Misc.	Measured Return To Date	Return Per Spawner
		(1978)	(1978)	(1979)	(1979)	(1980)			
1974	13,164	216	0	1,264	5,873	45,495	0	52,848	4.01
		(1979)	(1979)	(1980)	(1980)	(1981)			
1975	5,644	0	0	4,528	2,403	7,200	0	14,131	2.50
		(1980)	(1980)	(1981)	(1981)	(1982)			
1976	14,735	3,465	0	15,787	7,025	89,131	0	115,408	7.83
		(1981)	(1981)	(1982)	(1982)	(1983)			
1977	16,061	1,848	0	1,087	362	14,218	0	17,515	1.09
		(1982)	(1982)	(1983)	(1983)	(1984)			
1978	34,240	0	0	11,055	828	5,118	0	17,001	0.50
		(1983)	(1983)	(1984)	(1984)	(1985)			
1979	19,742	3,311	0	56,173	389	34,963	0	94,836	4.80
		(1984)	(1984)	(1985)	(1985)	(1986)			
1980	28,616	3,110	0	3,201	4,101	31,989	0	42,401	1.48
		(1985)	(1985)	(1986)	(1986)	(1987)			
1981	21,142	430	0	9,969	21,734	43,907	0	76,040	3.60
		(1986)	(1986)	(1987)	(1987)	(1988)			
1982	56,106	7,602	0	162,686	9,120	98,771	0	278,179	4.96
		(1987)	(1987)	(1988)	(1988)	(1989)			
1983	21,268	0	0	3,981	1,653	17,915	0	23,549	1.11

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Table 13.-Page 2 of 2.

Year	Spawning Escapement	Return Age 1.2	Age 2.1	Age 1.3	Age 2.2	Age 2.3	(1.4,2.4) Misc.	Measured Return To Date	Return Per Spawner
		(1988)	(1988)	(1989)	(1989)	(1990)			
1984	28,899	842	0	4,148	4,324	33,543	0	42,857	1.48
		(1989)	(1989)	(1990)	(1990)	(1991)			
1985	30,601	236	0	196	22,515	20,692	137	43,776	1.43
		(1990)	(1990)	(1991)	(1991)	(1992)			
1986	36,336	540	0	43,166	3,335	43,596	0	90,637	2.49
		(1991)	(1991)	(1992)	(1992)	(1993)			
1987	61,513	30,347	0	266	23,145	55,457	0	109,215	1.78
		(1992)	(1992)	(1993)	(1993)	(1994)			
1988	50,406		622	511	21,305	65,172	238	87,848	1.74
		(1993)	(1993)	(1994)	(1994)	(1995)			
1989	15,338	465	0	20,420	7,633	28,537		57,055	3.72
		(1994)	(1994)	(1995)	(1995)	(1996)			
1990	25,144	570	0	5,797	17,148	71,378		94,893	3.77
		(1995)	(1995)	(1996)	(1996)	(1997)			
1991	32,389	693	0	37,158	18,656			56,507	1.74
		(1996)	(1996)	(1997)	(1997)	(1998)			
1992	37,117	916	0					916	0.02
		(1997)	(1997)	(1998)	(1998)	(1999)			
1993	39,857							0	0.00
		(1998)	(1998)	(1999)	(1999)	(2000)			
1994	44,872							0	0.00
		(1999)	(1999)	(2000)	(2000)	(2001)			
1995	28,603							0	0.00
		(2000)	(2000)	(2001)	(2001)	(2002)			
1996	52,905							0	0.00

evidencing signs of abundance. However, it was determined that waiting a few more days through the weekend to observe how the fishery continued to develop, as well as tracking the weir escapements, was warranted.

By Monday, 17 June weir escapements had reached 25,612 fish with a final escapement projection off the charts at 1,343,900 fish. With the escapement goal of 16,000 readily surpassed, the decision to open the sanctuary area at the confluence of the Kenai and Russian rivers was deemed appropriate and the fishery was liberalized by opening the sanctuary area to fishing on Monday, 17 June, at 12:00 p.m. Anglers were therefore afforded increased fishing opportunity in 1996.

DISCUSSION

RELATIVE RUN STRENGTH

The strength of the 1996 early run, as determined from total return estimates (harvest plus escapement), was well above the 1976-1995 historical average (Figure 6). The early-run sockeye return of 1996 is the second largest return since formalized record keeping began in 1963. In addition, the run-timing of the 1996 early run was the earliest on record since run-timing statistics were developed for the sockeye salmon resource of the Russian River in 1978. The early-run return of 1996 generally maintains the trend, beginning in 1978, of greater numbers of early-run sockeye salmon returning to the Russian River system.

SAMPLE DESIGN

Creel Survey

An underlying assumption necessary for accurate harvest estimates is that most, if not all, anglers exit the fishery through one of the three sampled access locations. While anglers were observed using other exit locations, the level at which this occurred during 1996 appeared insignificant. Creel survey personnel and the project leader continued to maintain an informal accounting of the use of the other access sites at least twice a day during transit between other sites and during a shift change.

Observations of angler activity during the unsampled hours of 0000 to 0600 hours indicated that small numbers of fishermen were engaged in fishing at those hours during 1996. Once again, an informal accounting of the activity during these hours was accomplished through interviews with the angling public and frequent queries of the campground and ferry employees. Additionally, the project staff were instructed to maintain field notes in order to record the number of anglers observed fishing during non-surveyed hours. Generally, such observations occurred just prior to beginning the early morning shift (0600 hours) or after the completion of the sampling day (2400 hours). Further observations were made when project staff conducted personal fishing trips during non-surveyed hours. However, random observations of access locations during the nighttime period should be continued in the future. This will provide for any additional information regarding possible changes in angler use patterns which might prove useful in further refining the survey.

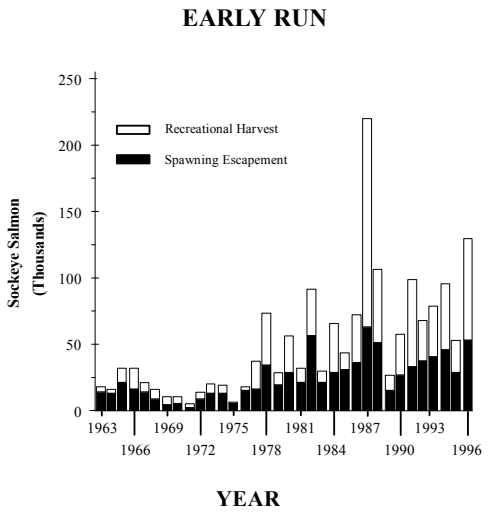

Figure 6.-Historical returns of early-run sockeye salmon to the Russian River.

Age Composition

The accurate assessment of the age composition of the sockeye salmon return is needed to establish accurate brood tables for the Russian River system. The sampling of time and area strata adopted in 1990 was continued in 1996. This increase in sampling intensity over prior years is an effort to achieve more accurate age composition estimates. Significant temporal changes in age composition have been detected among spatial strata within temporal strata since 1990 (Carlon et al. 1991, Marsh 1992-1996).

Statistical comparisons of the early-run age composition of the harvests and the weir escapement revealed that differences continued to occur in 1996. Therefore, it was not appropriate to use the age composition from one area to estimate the age composition of the total return. The age composition of the return was estimated separately for the recreational harvest and the weir escapement.

Because changes in the age composition of the early run were detected between areas in 1996, sampling of the individual spatial strata should continue at the present sampling intensity. This will improve both the estimates of the number of sockeye salmon returning by age and sex as well as evaluations of those differences over time. The end result will be improved accuracy of brood production information necessary for the long-term management of the Russian River system.

MANAGEMENT OF THE FISHERY

The utilization of migratory timing statistics derived from weir counts and fishery harvest rates should be continued (Vincent-Lang and Carlon 1991). The technique of fitting a migratory timing distribution function to count and harvest rate data has been used successfully in the Kenai River to project escapements of chinook salmon (McBride et al. 1989) and was adapted from techniques used to quantify migratory timing of chinook salmon in the Yukon River drainage (Mundy 1982). It is recommended that this technique should again be utilized in 1997 and subsequent years to further evaluate its value in managing the Russian River sockeye salmon resource.

ACKNOWLEDGMENTS

Steve Hammarstrom has provided a consistent and reasoned voice of experience regarding all aspects of the project, from personnel matters to migratory timing influences, which has served to increase my understanding of the project and the fishery resources of the Russian River.

Joe Richards collected creel survey interviews and age, sex, and length data from the sport fishery. This was Joe's second season at the Russian River, and he continued to perform his responsibilities in an exemplary manner In addition, Joe's personable conduct and high regard for co-workers was a much appreciated benefit to the project.

Amy Dolan collected creel survey interviews and age, sex, and length data from the sport fishery. This was Amy's first season at the Russian River. Amy provided a high measure of enthusiasm while performing her responsibilities which proved to be an invaluable asset to the Russian River project.

Troy Tydingco operated the Russian River weir and field camp. Troy was responsible for collecting biological data and conducting inriver escapement counts and sampling surveys. Troy continued to provide a new outlook towards making the field camp and weir facility a more efficient place to conduct the necessary research of studying the salmon resources of the Russian River drainage.

Dave Athons provided vital aircraft logistical support. Dave's prior work experience at the weir and knowledge of the sport fishery were

also valuable towards the day-to-day operations of the study.

Jim Hasbrouck provided statistical review of the data analysis necessary to estimate the age compositions of the sport harvest and the escapement as well as much appreciated critical review.

Dave Nelson provided a long-term perspective towards achieving project objectives.

Sandy Sonnichsen wrote and streamlined the SAS statistical analysis code necessary to generate harvest and effort estimates for the direct expansion creel design used for the Russian River project.

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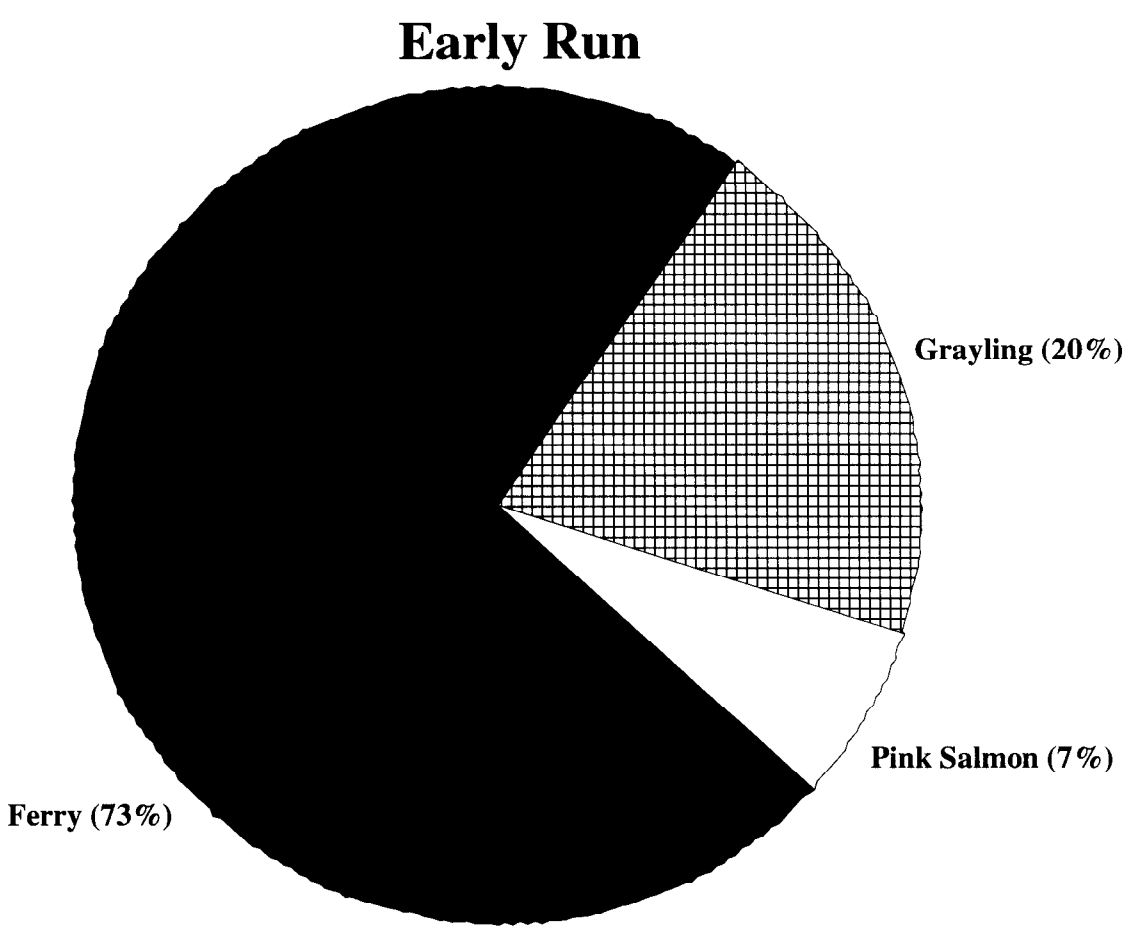
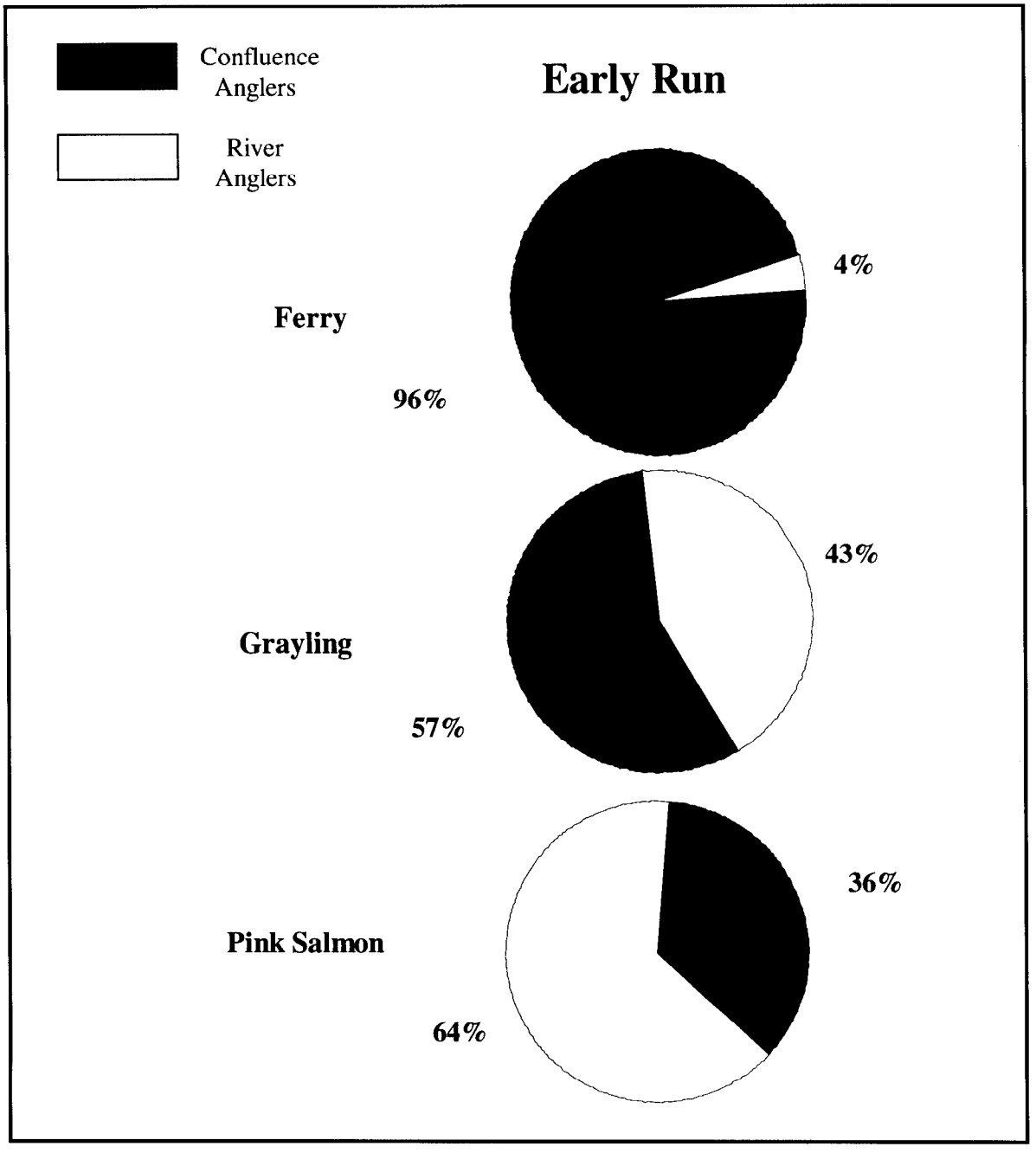
APPENDIX A. SELECTED SUMMARIES OF FISHERY AND ESCAPEMENT DATA FROM THE RUSSIAN RIVER, 1996.



Appendix A1.-Relative proportions of interviews collected at the sampled access locations to the Russian River sockeye salmon recreational fishery, early run, 1996.



Appendix A2.-Relative proportions of confluence and river anglers interviewed during the Russian River creel survey by access location, early run, 1996.

Appendix A3.-Temporal harvest and effort estimates for the 1996 early-run Russian River sockeye salmon recreational fishery by area and access location.

Location Exited	Temporal Period	D[a]	d[b]	Mean	Variance	Estimated Total Effort	Estimated Total Variance	Days	%	Periods	%	Anglers	%
River Effort:													
Ferry	6/11-6/29	19	10	230	65,063	4,361	1,550,118	1,112,571	72	437,251	28	296	0
Grayling	6/11-6/29	19	4	684	511,388	12,988	37,969,590	36,436,423	96	1,532,554	4	613	0
Pink Salmon	6/11-6/29	19	3	818	691,831	15,551	70,479,449	70,105,521	99	372,791	1	1,137	0
	Total 6/11-6/29					32,900	109,999,157						
Ferry	6/30-7/20	21	12	47	5,787	982	200,041	91,148	46	108,774	54	118	0
Grayling	6/30-7/20	21	7	407	59,048	8,537	4,082,544	2,480,000	61	1,602,373	39	171	0
Pink Salmon	6/30-7/20	21	5	139	16,527	2,923	1,160,249	1,110,623	96	49,471	4	154	0
	Total 6/30-7/20					12,442	5,442,834						
	Total River Effort					45,342	115,441,991						
Confluence Effort:													
Ferry	6/11-6/29	19	10	5,480	4,337,354	104,113	109,016,190	74,168,759	68	34,838,414	32	9,016	0
Grayling	6/11-6/29	19	4	1,386	1,846,993	26,328	132,673,415	131,598,273	99	1,072,881	1	2,261	0
Pink Salmon	6/11-6/29	19	3	472	175,161	8,975	17,843,713	17,749,697	99	93,010	1	1,007	0
	Total 6/11-6/29					139,416	259,533,318						
Ferry	6/30-7/20	21	12	1,154	530,258	24,228	10,227,157	8,351,569	82	1,873,902	18	1,687	0
Grayling	6/30-7/20	21	7	629	154,409	13,203	7,341,617	6,485,182	88	856,285	12	150	0
Pink Salmon	6/30-7/20	21	5	156	18,286	3,268	1,382,089	1,228,845	89	153,018	11	225	0
	Total 6/30-7/20					40,699	18,950,863						
	Total Confluence Effort					180,115	278,484,181						
	Total Effort					225,457	393,926,172						

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Location Exited	Temporal Period	D[a]	d[b]	Mean	Variance	Estimated Total Effort	Estimated Total Variance	Days	%	Periods	%	Anglers	%
River Harvest:													
Ferry	6/11-6/29	19	10	114	50,475	2,164	878,995	863,126	98	15,567	2	302	0
Grayling	6/11-6/29	19	4	310	333,908	5,893	23,957,798	23,790,927	99	166,350	1	521	0
Pink Salmon	6/11-6/29	19	3	331	433,442	6,284	43,926,044	43,922,157	100	2,717	0	1,170	0
	Total 6/11-6/29					14,341	68,762,837						
Ferry	6/30-7/20	21	12	17	930	349	38,179	14,640	38	23,403	61	136	0
Grayling	6/30-7/20	21	7	129	57,045	2,709	2,682,667	2,395,897	89	286,744	11	25	0
Pink Salmon	6/30-7/20	21	5	6	108	116	7,883	7,242	92	635	8	5	0
	Total 6/30-7/20					3,174	2,728,729						
	Total River Harvest					17,515	71,491,566						
Confluence Harvest:													
Ferry	6/11-6/29	19	10	2,058	1,820,239	39,095	33,996,790	31,126,085	92	2,864,407	8	6,298	0
Grayling	6/11-6/29	19	4	491	281,879	9,333	20,530,399	20,083,896	98	445,450	2	1,053	0
Pink Salmon	6/11-6/29	19	3	86	4,095	1,630	419,485	414,963	99	4,221	1	300	0
	Total 6/11-6/29					50,058	54,946,674						
Ferry	6/30-7/20	21	12	237	103,952	4,981	1,779,359	1,637,249	92	141,522	8	588	0
Grayling	6/30-7/20	21	7	114	7,617	2,397	410,693	319,910	78	90,751	22	32	0
Pink Salmon	6/30-7/20	21	5	12	192	252	14,468	12,904	89	1,564	11	0	0
	Total 6/30-7/20					7,630	2,204,520						
	Total Confluence Harvest					57,688	57,151,194						
	Total Harvest					75,203	128,642,760						

[a] D=days possible in a stratum.

[b] d=days sampled in a stratum.

Appendix A4.-Daily escapement of early- and late-run sockeye and chinook salmon through the Russian River weir, 7 June to 25 July 1996.

Date	Early Run Sockeye[a]	Late Run Sockeye	Chinook
6/7	4		
6/8	14		
6/9	945		
6/10	777		
6/11	3,616		
6/12	2,674		
6/13	2,460		
6/14	3,427		
6/15	4,050		
6/16	4,248		
6/17	3,397		
6/18	2,689		
6/19	132		
6/20	2,105		
6/21	5,835		
6/22	300		
6/23	212		
6/24	1,198		
6/25	5,315		
6/26	2,259		
6/27	1,149		
6/28	932		
6/29	1,139		
6/30	13		
7/1	208		
7/2	821		
7/3	303		
7/4	100		
7/5	296		
7/6	224		
7/7	297		
7/8	521		
7/9	252		
7/10	17		
7/11	268		
7/12	9		
7/13	35		
7/14	14		
7/15	19		
7/16	208	13	1
7/17	245	12	
7/18	45	7	
7/19	6	2	
7/20	3	0	
7/21	0	0	
7/22	15	20	
7/23	21	16	
7/24	64	1,602	
7/25	24	254	
Total	52,905		

[a] From 7/16 through 7/25, early-run fish were differentiated from late-run fish based on degree of external maturation, i.e., body coloration and kype development. There was a 10-day overlap between early-run and late-run fish. The total late-run sockeye salmon escapement is tabulated in the Fishery Data Series report for the 1996 late run to the Russian River (Marsh *In prep*).

[b] Total estimated chinook escapement is tabulated in the Fishery Data Series report for the 1996 late run to the Russian River (Marsh *In prep*).